

Contents

Foreword ix

Preface xi

Acknowledgments xv

List of Contributors xvii

1. A Systematic View of Remote Sensing 1

- 1.1. Introduction 2
- 1.2. Platform and Sensor System 2
- 1.3. Data Transmission and Ground Receiving System 11
- 1.4. Data Processing System 14
- 1.5. Mapping Category Variables 18
- 1.6. Estimating Quantitative Variables 22
- 1.7. Production, Archiving, and Distribution of High-level Products 27
- 1.8. Product Validation 28
- 1.9. Remote Sensing Applications 28
- 1.10. Concluding Remarks 30
- References 30

Geometric Processing and Positioning Techniques 33

- 2.1. Overview 34
- 2.2. Geometric Calibration of Satellite Remote-Sensing Imagery 36
- 2.3. Geometric Rectification of a Single Remote-Sensing Image 43
- 2.4. Geometric Registration of Satellite Remote-Sensing Imagery 53
- 2.5. Construction of a Digital Terrain Model 60
- 2.6. Orthoimage Production 64
- 2.7. Summary 72
- References 73

Compositing, Smoothing, and Gap-Filling Techniques 75

- 3.1. Multitemporal Compositing Techniques 76
- 3.2. Time-series Data Smoothing and Gap-filling 81
- 3.3. Summary 88
- References 89

4. Data Fusion 91

- 4.1. An Overview of Remote-Sensing Data Fusion 92
- 4.2. Methods for Pixel-level Remote-Sensing Data Fusion 94
- 4.3. Generalized Model for Pixel-level Remote-Sensing Data Fusion 101
- 4.4. Heterogeneous Data Source Fusion Technique 103
- 4.5. Summary 104
- References 107

5. Atmospheric Correction of Optical Imagery 111

- 5.1. Atmospheric Effects 112
- 5.2. Correcting the Aerosol Impact 114
- 5.3. Correcting the Impact of Water Vapor 121
- 5.4. Correcting the Impacts of Other Constituents 122
- 5.5. Commonly Used Models and Software 122
- 5.6. Conclusions 124
- References 125

6. Solar Radiation 127

- 6.1. Basic Concepts 128
- 6.2. Observation Network of Land-Surface Radiation 131

6.3. Surface Radiation Estimation Based on Satellite Remote Sensing and Global Circulation Model GCM	136	Canopy Biochemical Characteristics	301
6.4. Summary and Discussions	163	10.1. Overview of Principles and Methods	302
Nomenclature	169	10.2. Empirical and Semi-empirical Methods	313
References	170	10.3. Extraction Using Physical Models	328
7. Broadband Albedo	175	10.4. Conclusions and Discussions	343
7.1. Land-Surface Bi-Directional Reflectance Modeling	177	References	344
7.2. The Albedo Estimation Method Based on Bi-directional Reflectance Model Inversion	194	11. Leaf Area Index	347
7.3. The Direct Estimation of Surface Albedo	197	11.1. Definitions	348
7.4. Joint Optimization of Surface-Atmospheric Parameters	207	11.2. Statistical Methods	351
7.5. Global Land-Surface Albedo Products	213	11.3. Canopy Model Inversion Methods	353
7.6. Temporal and Spatial Analysis of the Global Land-Surface Albedo	217	11.4. Data Assimilation Methods	370
7.7. Problems and Prospects	227	11.5. Global and Regional LAI Products	375
References	228	11.6. LAI Climatology	377
8. Land-Surface Temperature and Thermal Infrared Emissivity	235	11.7. Summary	378
8.1. The Definitions of LST and LSE	236	References	380
8.2. The Estimation of Average LST	239	12. Fraction of Absorbed Photosynthetically Active Radiation by Green Vegetation	383
8.3. LSE Estimation Methods	248	12.1. Definitions	384
8.4. LSE and LST Products	265	12.2. FAPAR Field Measurements	385
8.5. Summary	267	12.3. Monte Carlo (MC) simulation	386
Acronyms	268	12.4. Empirical Retrieval Methods	393
References	268	12.5. Popular Remote-Sensing FAPAR Products	395
9. Surface Longwave Radiation Budget	273	12.6. FAPAR Retrieval Method Based on the Hybrid Vegetation Spectral Model	400
9.1. Surface Downward Longwave Radiation	274	12.7. Case Study	406
9.2. Surface Upwelling Longwave Radiation	287	12.8. Summary	411
9.3. Surface Net Longwave Radiation	292	References	412
9.4. Ground Validation Networks and Existing Satellite-Derived Surface Longwave Radiation Budget Products	293	13. Fractional Vegetation Cover	415
9.5. Summary	296	13.1. Introduction	416
References	296	13.2. Field Measurements of FVC	416
		13.3. The Remote-Sensing Retrieval	422
		13.4. Current Remote-Sensing Products	433
		13.5. Challenges and Prospects for FVC Estimation	435
		References	436

14. Vegetation Height and Vertical Structure	439	18. Terrestrial Evapotranspiration	557
14.1. Field Measurement of Vegetation Height and Vertical Structure	440	18.1. Introduction	557
14.2. Small-Footprint Lidar Data	443	18.2. Basic Theories of λE	562
14.3. Large-Footprint Lidar Data	449	18.3. Satellite λE Algorithms	565
14.4. Vegetation Canopy Height and Vertical Structure from SAR Data	452	18.4. Observations for Algorithm Calibration and Validation	576
14.5. Future Perspectives	464	18.5. Conclusions and Discussion	579
References	464	Acknowledgements	581
		References	581
15. Above-ground Biomass	467	19. Soil Moisture Content	589
15.1. Introduction	467	19.1. Introduction	589
15.2. Allocation Methods	468	19.2. Conventional SMC Measurement Techniques	590
15.3. Optical Remote-sensing Methods	471	19.3. Microwave Remote-Sensing Methods	593
15.4. Active Remote Sensing Methods	480	19.4. Optical and Thermal-IR Remote-Sensing Methods	602
15.5. Methods for Biomass Estimation from Multisource Data	488	19.5. Estimation of Soil Moisture Profile	608
15.6. Future Perspective	492	19.6. Comparison of Different Remote-Sensing Techniques	609
References	493	19.7. Available Datasets and Spatial and Temporal Variations	609
Vegetation Production in Terrestrial Ecosystems	501	19.8. Conclusions	612
16.1. Concept of Vegetation Production	502	References	612
16.2. Ground Observation of Vegetation Production	503	20. Snow Water Equivalence	615
16.3. Statistical Models Based on the Vegetation Index	506	20.1. Passive Microwave Remote-Sensing Techniques	616
16.4. Light-Use Efficiency Model Based on Remote-Sensing data	508	20.2. Active Microwave Remote-Sensing Techniques	639
16.5. Dynamic Global Vegetation Models (DGVMs)	521	20.3. Visible Band Remote-Sensing Techniques	649
16.6. Temporal and Spatial Distribution Pattern of Global Vegetation Productivity	526	20.4. Summary	651
16.7. Summary	528	References	653
References	528	21. Water Storage	655
Precipitation	533	21.1. Water-Balance-Based Estimation	656
17.1. Surface Measurement Techniques	534	21.2. Surface-Parameter-based Estimation	656
17.2. Estimation from Satellite Data	536	21.3. GRACE-based Estimation	660
17.3. Global and Regional Datasets	541	21.4. Discussion and Future Prospects	663
17.4. Global Precipitation Climatology	549	References	664
17.5. Future Perspectives	552		
References	554		

22. High-level Land Product Integration	667	23.3. Production System	692
22.1. Introduction	668	23.4. Data Management System	699
22.2. Geostatistical Methods	672	23.5. Summary	701
22.3. Multiresolution Tree	672	References	701
22.4. Empirical Orthogonal Function (EOF)-based Methods	680	Land-cover and Land-use Changes	703
22.5. Summary	686	24.1. Introduction	704
References	687	24.2. Urbanization	705
Production and Data Management Systems	691	24.3. Intensive Agriculture	719
23.1. Overview of the Production and Database Management	691	24.4. Forest Cover Changes	738
23.2. System Hardware	692	24.5. Conclusions	763
		References	764
		Index	773